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NRM2-50-0302

POWER SYSTEMS

B+W EXHIBIT 543 FOR IDENT.
3/19/82 M. A. RUDOLPH

October 14, 1977
TD-CE-900

Tennessee Valley Authority
400 Commerce Avenue
Knoxville, Tennessee 37902

Attention: Mr. D. R. Patterson, W10C126
Chief Mechanical Engineer

Gentlemen:

Subject: Nuclear Steam Supply Systems
Proposed Yellow Creek Plant
TVA Order No. 60-84840
C-E Contracts 14074 and 14174
VERY SMALL BREAK LOCA

Reference: A) TVA letter C-655, dated July 22, 1977.

The attachment to this letter responds to the TVA concerns, expressed in Reference A, regarding a very small break LOCA.

It should be noted that the small break post-LOCA long term cooling analyses and procedures discussed herein are based on methodologies undergoing current review by the NRC. It is expected that NRC review of these topical reports will not be completed before April 1, 1978.

Very truly yours,

R. L. Lumpkin, Jr.
for Project Manager

RLL/TEM:dfm
T-PPE-160

cc: M. J. Epprecht, C-E
W. Wade, TVA

OCT 18 1977

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C-E Response to the TVA Concerns Regarding Very Small Break LOCA

Assumptions:

1. To assess the impact of a non-condensible gas on steam generator heat transfer during a small break LOCA, the presence of hydrogen in the Reactor Coolant System (RCS) was investigated. Calculations performed with the assumption that one percent of the core wide clad reacts prior to the onset of primary steam condensation and all of the gas evolved is assumed to collect in the steam generators, resulted in a reduction in heat transfer rate of only six percent. Reaction rates typical of the small break LOCA response demonstrate reaction percentages much less than 0.1% prior to the start of condensation. Consideration of SIT N_2 injection is not necessary for these small breaks because the SIT's do not inject during these transients. Since the condensation coefficient utilized in the small break LOCA transient calculations are based on conservatively low values, (50 percent lower than best estimate values) the small reductions in heat transfer rates, as a result of non-condensible gases in the system, are more than bounded by the conservatism in the heat transfer model.

2. Throttling of the HPSI pump(s) is required to enter shutdown cooling for breaks small enough that the Safety Injection System can keep the RCS pressurized above 400 psia. The operator will gradually close valves in the HPSI pump discharge lines until the RCS pressure is reduced below 400 psia, as indicated by the pressurizer pressure. Remote position indicators on these valves and HPSIP flow meters (F-311, 321, 331, 341) will aid the operator during this process. It is understood that the conflicting information contained in TD-CE-660 has been rectified by subsequent correspondence.

3. The small break LOCA analysis does not account for operation of the Chemical and Volume Control System (CVCS).

4. The small break LOCA spectrum includes analysis of break sizes with areas in the range of 0.5 to approximately 0.0005 ft^2. The lower limit is chosen consistent with that break size at which the leak flow is matched by the charging flow at full power conditions. For a given cold leg break, increased leakage assumed from the reactor coolant pump seals would define a larger equivalent break size with the transient response accommodated in the above defined spectrum. Breaks larger than 0.5 ft^2 are accommodated in the large break spectrum.

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Transient Analysis:

5. With natural circulation referring to the initial subcooled portion of the small break LOCA and boiling referring to the condition when the RCS fluid achieves saturation, the following heat removal mechanism in the core and steam generator are:

	RCS Fluid State	Core Heat Transfer	Steam Generator Heat Transfer
1)	Subcooled	Forced Convection	Forced Convection
2)	Saturated	Flow or Pool Nucleate Boiling	Two Phase Flow With Condensation

The time the transition from a subcooled forced convection condition to boiling (saturated condition) is achieved in the core will vary with break size from about five seconds for a 0.5 ft^2 break to about 40 seconds for a 0.05 ft^2 break.

6. The hot and cold leg fluid temperatures at the time the transition from a subcooled to a saturated condition in the core occurs will vary somewhat with break size. For scoping purposes, for the range of break sizes 0.5 ft^2 to 0.05 ft^2, the hot and cold leg temperatures will be very near to the temperatures at initial full power conditions. This information will be provided at a later date when the Final Safety Analysis has been completed.

7. Operation of the main coolant pumps during a small break LOCA benefits the transient response by delaying or preventing core uncovery. Core uncovery is defined as that condition during a small break LOCA where the two phase level recedes below the top of the active core region. The pressure drop generated by operation of the main coolant pumps can support a higher fluid level in the inner vessel region (lower plenum, core, and upper plenum of the reactor vessel) relative to the condition with the coolant pump shut off, so that the potential for core uncovery occurring during the transient is either minimized or prevented.

8. If the break is isolated during the transition to boiling or during the boiling mode, the high pressure safety injection pumps will refill the RCS at a faster rate as compared to the refill rate prior to isolation.

9. The unit operator will have at least the following instrumentation available: (1) pressurizer pressure; and (2) RCS temperature. These instruments are redundant safety channels supplied with emergency power and qualified for post-accident service.

Recovery:

10. The safety injection pumps and the auxiliary feedwater pumps are automatically actuated by the safety injection actuation signal and the emergency feedwater actuation signal, respectively. At one hour after the LOCA, the operator initiates cooldown to the steam generators by supplying feedwater and relieving steam. Steam is relieved through the turbine bypass system if AC power is available or through the atmospheric dump system if power is unavailable. Then at two hours after the LOCA, the high pressure safety injection (HPSI) pump discharge lines are realigned so that the total injection flow is divided equally between the hot and the cold legs to maintain core cooling and boric acid flushing.

At eight hours after the LOCA, if RCS pressure has remained above a specified pressure, the RCS is filled with liquid water and there is assurance that all conditions for entering the shutdown cooling mode can be established. Cooling of the RCS with the steam generators continues until the shutdown cooling entry temperature is achieved. The HPSI pumps are then throttled until RCS pressure is reduced to the shutdown cooling entry pressure. Next, all injection flow is shifted back to the cold legs and shutdown cooling is initiated.

If RCS pressure at eight hours has fallen (or remained) below the specifie pressure, the break may be too large for absolute assurance that proper suction is available for the shutdown cooling mode; however, in this event, there is assurance that simultaneous hot leg/cold leg injection alo will both cool the core and flush the reactor vessel indefinitely.

11a. The heat removal mechanism during the transition from boiling (saturated RCS condition) to natural circulation (a subcooled RCS condition) are given in the response to Question 5.

11b. The time transition from boiling to natural circulation (when the RCS refills) will vary with break size. Depending on the break size, this transition will occur from approximately two to eight hours following initiation of LOCA's with break sizes in the approximate range, 0.0005 to 0.05 ft^2, respectively.

11c. Refilling of the RCS and hence the steam generators is accomplished throu injection from the high pressure safety injection pumps. The HPSI pumps have sufficiently high shutoff head to continue injecting until the RCS becomes refilled and subcooled.

12a. Shutdown cooling is not to be initiated in the boiling mode. As described in the response to Question 10, if the RCS is in the boiling mode (RCS pressure is less than a specified pressure, eight hour post-LOCA, indicating a large break) hot side/cold side injection will cool the core indefinitely. provided you go on with [illegible]

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Recovery (continued):

12b. The unit operator will have at least the pressurizer pressure and RCS temperature instrumentation available, as described in the response to Question 9.

13a. The LPSI pumps will take suction on the hot legs in the normal manner of shutdown cooling initiation. contrary to 12a.

13b. The high pressure safety injection would continue to function upon RAS. A portion of the stream which was flowing through the minimum flow line will provide some additional injection flowrate. The total injection flowrate following RAS will be in excess of the minimum flow required for the HPSI pumps.

13c. Please refer to the response to Question 2.

14. The SIT's must be vented to reduce pressure to 400 psig by using vent valves SI-605, 606, 607, 608, and/or SI-613, 623, 633, 643. In addition, the SIT discharge valves, SI-614, 624, 634, 644, will be closed when the RCS pressure drops to the SIT pressure, approximately 415 psia.

15. As discussed in the response to Question 10, if after eight hours the RCS pressure is above a specified pressure, the RCS has been refilled and there is assurance shutdown cooling can be initiated. If the RCS pressure is less than a specified pressure, the break may be too large for absolute assurance that proper suction is available for the shutdown cooling mode; however, simultaneous hot leg/cold leg injection alone will both cool and flush the reactor vessel indefinitely. The capacity of the condensate storage tank translates to about 16 hours of cooling capability, based upon the interface requirment of 300,000 gallons.

General:

16. The detailed emergency procedures are not available at this time.

17. C-E is currently performing the analysis required to obtain this information and will respond in separate correspondence.

18. As agreed upon during the telecon with TVA, question 18 will be answered for the 0.1 ft^2 break. Assuming two condensate storage pumps and one HPSI pump operating, and 469,000 gallons in the RWT, the time to RAS would be about 48 to 55 minutes.

General (continued):

19. The mechanical stresses imposed on the steam generator tubes by the pressure pulses associated with the transition from natural circulation to boiling and back to natural circulation, are no greater than the stresses imposed by the flow transition during the loss of coolant accident.

20. As discussed in the response to Question 10, if the RCS pressure is above a specified pressure eight hours following initiation of the transient, the RCS has refilled (and is in the natural circulation mode) and shutdown cooling can be initiated. If the RCS pressure is less than a specified pressure (the RCS is not refilled and is in the boiling mode) eight hours following the initiation of the LOCA, the break is too large for absolute assurance that shutdown cooling can be initiated. However, hot side/cold side injection alone will cool and flush the reactor vessel indefinitely. Thus, establishing natural circulation (a subcooled RCS fluid state) is not a requirement to recover from the transient.